How Mobile Money Platforms and Other Innovative Technologies Have Stimulated Energy Revolution in Rural Sub-Saharan Africa

HOW MOBILE MONEY PLATFORMS AND OTHER INNOVATIVE TECHNOLOGIES HAVE STIMULATED ENERGY REVOLUTION IN RURAL SUB-SAHARAN AFRICA

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ABSTRACT: Sub-Saharan Africa continues to suffer energy poverty due to low grid expansion rates necessitated by low economic activities in those regions, sparse population distribution coupled with low household load demands, and insufficient power generation. On the other hand, small solar power microgeneration systems have emerged as potential alternatives to grid electrifications, enabling households to make modest investments into their power systems, and to modify their systems according to their changing economic and power demand circumstances. Innovative mobile money platforms have created an atmosphere of financial inclusivity, enabling people in remote rural areas to carry out financial transactions over long distances using the most basic of mobile phones, thus connecting them to the formal economy. In addition to creating many avenues for trade, job creation, and innovation, the mobile money platforms have also acted as catalysts for innovating energy models, access, and trade. Now, most businesses involved in energy generation and trade rely on these platforms for their financial transactions. This enables remote running and operation of energy generation and management systems. The energy consumers also use the platforms to pay for their power, and to modify their power bundles according to their needs/incomes. Emergence of pay-as-you-go (PAYG) companies has seen steep rise in PV installations in the area due to provision of microcredit facilities, enabled by mobile money platforms.

Keywords: Mobile Money; Pay-As-You-Go (PAYG); Minigrids; Rural Electrification

1 INTRODUCTION

Electricity is crucial to rural socio-economic development and easy access to it is an indicator of a nation's standard of living. International Energy Agency (IEA) estimates that over 588 million people in sub-Saharan Africa do not have access to electricity, and that 84% of these people reside in rural areas, and this number is projected to rapidly increase as Africa's population continues to grow at a faster pace than of its grid extensions [1]. It is further estimated that these people spend about $14 billion annually on lighting, usually on kerosene, rechargeable batteries, firewood, and charcoal, not accounting for travel times and high kerosene prices in off-grid areas [2,3]. In addition to the fuel costs, it is estimated that these unelectrified households spend about $5 billion annually on mobile-phone charging, usually at small-businesses, at costs of between $0.15-0.25/charge, not accounting for travel costs [4].

Region	Rate of access			Population without access (million)
	National	Urban	Rural	
	2016	2016	2016	2016
WORLD	**86%**	**96%**	**73%**	**1060**
Developing Countries	**82%**	**94%**	**70%**	**1060**
Africa	**52%**	**77%**	**32%**	**588**
North Africa	100%	100%	99%	<1
Sub-Saharan Africa	43%	71%	23%	588
Developing Asia	**89%**	**97%**	**81%**	**439**
China	100%	100%	100%	-
India	82%	97%	74%	239
Indonesia	91%	99%	82%	23
Other Southeast Asia	89%	97%	82%	42
Other Developing Asia	73%	87%	65%	135
Central and South America	**97%**	**98%**	**86%**	**17**
Middle East	**93%**	**98%**	**79%**	**17**

Table 1: Electricity Access 2016 - Regional Summary [1]

IEA estimates that only 30% of the people currently without access to electricity in sub-Saharan Africa can be cost-effectively served through national grid extensions due to the sparseness of the rural populations, rough terrains, low economic activities, and low load densities; the remaining 70% would be cost-effectively served through decentralized microgeneration systems [1]. The modular nature of microgeneration technologies allows for phased project implementations, enabling households and communities to initiate modest power generation programs, and to modify their systems according to their changing energy needs. Depending on local resources, capacities, designs and technologies used, microgeneration systems could provide the final solutions to rural electrification in many developing nations and entrench green economies in the process. In fact, it is estimated that there will be almost 400TWh of installed microgeneration capacity by 2030, about 40% of new installed capacities towards universal electrification in developing nations [1]. Even though the grid expansion has outpaced population growth in many countries, this is not the case in sub-Saharan Africa. Between 2010 and

2017, the grid coverage only increased by 7%, leading to less than 40% of overall coverage [1,5]. Moreover, the grid still remains highly unreliable, with blackouts a constant occurrence in these regions. The slow grid growth, together with unreliability of the grid, rapid population growth, and small SHS requiring replacements every 2-4 years, has made the size of the potential market for off-grid solar sector to stay largely stagnant, even with exponential growth in SHS sales and installations in the region [5].

Off-grid solar sector has seen big growth over the last decade, driven mainly by sales of pico-scale systems with capacities below 10Wp [6]. Over 130 million solar home systems (SHS) were sold between 2010 and 2017, representing a 60% growth in sales, and a 17% growth in market penetration [7]. In the same period, annual investments in off-grid solar systems have continues to grow, with $922 million being raised since 2012, and $284 million being raised in 2017 alone [7]. Today, it is estimated that about 73 million households are electrified using off-grid solar microgeneration systems, representing about 360 million people [7,8]. These households have basically switched from kerosene and harmful biomass fuels to small solar home systems, in the process saving approximately $5.2 billion in fuel purchases and avoiding emitting 28.6 million tons of greenhouse gases to the environment. Moreover, switching to a cleaner form of energy has resulted in an increase of 45% in general good health and quality of living, and especially in a reduction in respiratory and eye infections, and in burns and accidents [9]. In addition to lighting, about 1.9 million people also use SHS for micro-enterprises to augment their incomes [8,9].

The growth in off-grid solar sector has seen the emergence of three main product categories, i.e., pico systems, plug-and-play systems, and component-based system, catering for lighting and beyond (e.g. communication, cooking, entertainment, refrigeration, and water pumping), and two distinct business models, i.e., cash-based systems versus pay-as-you-go (PAYG) systems. Pico-level solar home systems (SHS) act as electrification stimulators, introducing households and individuals to the benefits of electricity with modest initial investments, while allowing them to temporally climb the energy ladder, as shown in figure 1 [10], by modifying their systems with increasing incomes and demands, and with changing technologies. Before the introduction of PAYG, 97% of pico-solar technologies sold were solar lanterns as majority of households could not afford up-front costs of the SHS.

It is estimates that off-grid solar sector will continue to see strong growth in the next five years, with total sales increasing by about 25% and annual revenues growing to about $8 billion [6-8]. PAYG companies will be the main growth drivers, accounting for over 20 million units in annual sales, or up to 90% growth, and for about $6-7 billion in annual revenues by 2022 [6-8]. During the same period, the total number of people electrified through off-grid solar systems will also grow from 360 million to over 740 million by 2022 [6-8]. Increasing real income growths, improved distribution networks, improved performances of PV systems and off PAYG technologies, and introduction of conducive policies are some of the few factors that will dive this growth.

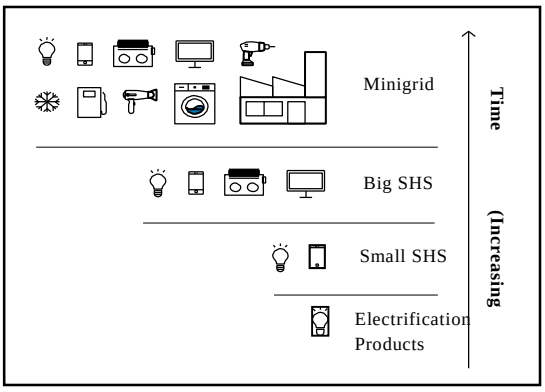

Fig 1: Energy Ladder [10]

2 TECHNOLOGY LEAPFROG

Innovative mobile money platforms have created an atmosphere of financial inclusivity, enabling people in remote rural areas to carry out financial transactions over long distances using the most basic of mobile phones, thus connecting them to the formal economy. In addition to creating many avenues for trade, job creation, and innovation, the mobile money platforms have also acted as catalysts for innovating energy models, access, and trade. Now, most businesses involved in energy generation and trade rely on these platforms for their financial transactions. This enables remote running and operation of energy generation and management systems. The energy consumers also use the platforms to pay for their power, and to modify their power bundles according to their needs/incomes.

In addition to mobile money platforms, locally designed smart meters, and satellite imagery have rapidly driven down the cost of setting up and running PV power systems and businesses. Companies such as PowerHive use satellite imagery and GIS to remotely find and characterize potential minigrid sites [11]. Some companies such as SteamaCo have developed their own robust and affordable smart metering systems that can operate in areas with very poor mobile connectivity [12]. Vulcan Philanthropy has focused on market research, and in particularly oh how frequency of mobile phone usage correlated with an individual's/business's power demands. They have concluded that the most frequent phone users are the higher power consumers, but that this needs to be complement with a strong residential consumers' base [13]. The illustration below shows how technologies boost minigrid business in Kenya.

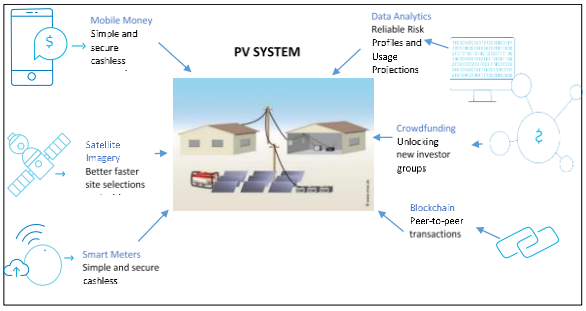

Fig 2: Technology Leapfrog

Other applications of technology in acceleration of PV installations include crowdsource funding for minigrids, allowing investors to buy individual solar cells or modules within a specific solar-power minigrid project. Examples include projects by Sun Exchange in South Africa and by Swedish Trine platform [14]. Peer-to-peer power trade without going through a centralized operator, enabled by blockchain platform, could be used by community-owned minigrids, minigrids based on a collection of many solar home systems, by regional grids composed of many integrated minigrids, or by minigrids integrating with the national grid. An example is the Brooklyn Minigrid built by LO3 [15]. In Kenya, the start-up Lendable wants to use big data analytics to provide potential investors and lenders with information on the bankability of consumers and service providers at given locations [16]. This would enable easy financial decision making vis-à-vis funding minigrid investments in the region.

3 THE PAY-AS-YOU-GO (PAYG) MODEL

The realization of the importance of lifetime values of consumers, as opposed to one-off cash-based transactions, has led to the emergence of PAYG companies that support pug-and-play and component-based product systems. These new market entrants use this model to build long-terms transactional relationships with consumers, leading to increased sales and revenues by as much as 140%, and to a slowdown in cash-based sales of pico systems by as much as 60%, over the past 3 years [7]. Even though PAYG systems account for less than 5% of total market sales today, they account for between 20% and 30% of total revenue generated by the sector annual, and are expected to dominated the market in the next 3-5 years [7]. These growths have seen an increase in commitment of resources from development institutions and partners to the off-grid solar sector, with than 25 countries now engaged with world bank to build capacity and deploy funding towards off-grid solar sector in sub-Saharan Africa [9]; PAYG companies have attracted increasing commitment from investors, including commercial debt and equity players over the past 5 years, accounting for 85% of all investments towards the off-grid solar sector between 2012 and 2017, or about %773 million of cash raised, with $500 million being raised in the last 2 years alone [7-9].

PAYG companies combine energy products and debt services into one big system, and thus a means to consumer banking. These systems are mainly supported by mobile money platform, and thus initially found root in Eastern Africa; Kenya accounted for 30% of reported SHS sales by PAYG companies in Africa from July 2015- July 2017, with Ethiopia and Tanzania together making up another 30% [6,8]. Outside of Kenya, an estimated 50% of PAYG consumers opened mobile money accounts specifically to pay for electricity [17]. The PAY platform offers many opportunities for energy companies, including:

- The combined energy products and financial services approach allows for a wide range of product packages such as small DC appliances with a core with solar home system, driven by increasing demand; it is estimated that over 22 million households in sub-Saharan Africa will be using solar-powered TV and/or fans by 2020 due to such packages [6,8]
- These platforms lead to acquisition and aggregation of large amount of data on power generation, power usage patterns, and consumer payments. The data can be used for credit scoring and to tailor systems for specific consumers. Monetary value of this data is therefore important for the sector's valuation.
- The systems lead to establishments of strong and lifelong consumer-vendor relations, with the data give during the life of the customer, used to customize the customer's products according to his needs, thus making it harder for new entrants into the market, to snatch away such a customer [18].

It is estimated that PAYG will expand in the next five years to reach more consumer and drive market growth. Improved appliances affordability and reliability will drive sales, while also boosting SHS purchases. Companies such as M-Kopa now sell self-branded TVs and other appliances, with an estimated 70,000 units sold by July 2017 [19]. Unpenetrated areas, such as DRC Congo will provide new market opportunities. Few countries have achieved market penetration of over 20%, and therefore opportunity for growth is still available.

3.1 Challenges to PAYG Systems

Before full market potential is realized, PAYG companies must address certain challenges to their expansion and growth. Amongst the main challenges are:

- Most PAYG companies comprise of four business sub-systems operating as one, i.e., they design, make or assemble their own products, they create or have their own distribution networks, they create their own PAYG apps for use on mobile platforms, and they also run their own payments/credit systems. Managing, and excelling, and all their sub-systems is difficult.
- Low-cost generic products account for more than half of SHS sales in sub-Saharan Africa, risking undermining the growth of the market by putting-off newly won consumers whose systems fail after a short time [20]. Generic products comprise those that are not branded, copycats, and counterfeits. Counterfeits damage both a brand's reputation and the overall SHS market. They hinder legitimate businesses from capturing the value they create [20,21]. Due to low barriers to market entry and low costs, generic products will continue to attract both manufacturers and consumer, risking market spoilage as only 26% of consumers can tell fake products from genuine ones [20]. Retailers and consumers are attracted to the low prices, which could be as much as 44% cheaper than branded products, and often choose the low price over quality products. For example, 97% of all SHS sold in Tanzania in the financial year ending 2015 were generic [20]. On the other hand, a market research in Kenya showed that the share of actual counterfeits is less than 2% [21].
- There is increased competition from new market entrants, some with unique advantages, such as Angaza, a PAYG platform developer that is now

allowing new market entrants to leapfrog technology development requirements. Some, such has D.Light have vast experience in product development, and are using this heritage to exploit existing distribution networks. Existing players therefore have to find means of effectively responding to these new entrants, in order to keep afloat.

- Even with pay-as-you-go systems, most rural consumers still cannot afford to pay for services, or packages, beyond lighting due to high level of poverty. This means that they cannot develop socio-economically as electricity beyond lighting is required for one to realize full benefit of electricity. PAYG companies therefore usually serve the most well-off in a given rural community.
- PAYG companies collect lots of consumer data that could be easily stolen and/or misused to reduce the consumer's bargaining power. This presents a major ethical dilemma, as the data is important for credit-rating of consumers, and also for raising funds, while at the same time presents a major exploitable information on consumers.

3.2 Potential Solutions to PAYG Challenges

- PAYG companies should specialize in one business and outsource the others. Some companies like D.Light should specialize on product development, a niche they have created for many years, while others like Angaza should specialize in PAYG platform (app) development, also, something they have specialized in for years.
- Lighting Africa and Lighting Global developed a testing framework for quality assurance that has now been accepted by the international electrical committee as a technical specification IEC/TS 62257-9-5 and has been integrated into nationwide programs by Kenya, Ethiopia, Liberia, and Bangladesh. The quality assurance programme has been adopted as a pre-condition for receive carbon credit finance under the UN Framework Convention on Climate Change (UNFCCC), and ECOWAS has referenced it as it adopts a new quality framework for pico-solar products [6]. This should be adopted by all PAYG companies in order to limit influx of generic products into the market.
- Explore productive use applications of SHS as means of generating more revenue. These could be in the form of food preservation/refrigeration, water pumping and irrigation, entertainment, etc. The companies could hire out appliances for these services, or make these services part of the PAYG package.
- The companies should link sales targets and incentives to long term customer values, to help achieve a healthy balance sheet.
- PAYG companies should establish ways to protect customers from potential data breach and/or abuse. These should include banning of misleading advertisements, developing clear industry guidelines/policies on how customers' data can be handled, shared, and used [22, 23]

3.3 Examples of PAYG Companies

PAYG companies target low-income rural consumers with payment plans for SHS, with the consumer receiving the systems after making a down payment of about $30 for a basic system, followed by regular payments of about $0.30-0.50/day to access the energy from the system. For larger systems with more facilities such as small DC-powered TVs and extra mobile phone chargers, the daily payment could be as high as $2/day [24]. Payments are usually made via mobile money platforms such as M-Pesa, via scratch cards, or via cash payments. The SHS kit stops working if payments are in arrears. The customer gets to own the SHS kit once all scheduled payments have been made.

More than 20 companies now offer SHS based on PAYG financial models in sub-Saharan Africa. The most common ones are in Kenya, Tanzania, Rwanda, and Uganda, with M-Kopa, Mobisol, Off-Grid Electric, Fenix International, and BBOXX being the main players. Other companies include VillagePower, SolarNow, SunTransfer, Mibawa, Eternum Energy, and EEG Energy. In West Africa, Nova Lumos, PEG Ghana (franchisee of M-Kopa), and Oolu Solar are the main operators, especially in Nigeria, Ghana, and Senegal. Azuri systems are found in many sub-Saharan Africa countries, including South Africa and Zimbabwe. These African countries have high off-grid populations with mobile phone access and score high in ease of doing business survey and in clean-energy investment readiness ranking [25,26]. The main PAYG companies operating in sub-Saharan Africa are profiled below:

3.3.1M-Kopa

M-Kopa mainly operates in Kenya, Uganda, and Tanzania, and offers mainly two systems [19]: The first is M-Kopa 5, which comprises an 8Wp solar panel, control unit with Li-Ion battery, four 1.2W LED bulbs, rechargeable torch, rechargeable FM/AM radio, 5-in-1 phone charger, and a custom charge cable. The second is M-Kopa 400 that comes with a 20Wp solar panel, a 20" digital TV, 3 LED light bulbs, rechargeable torch, rechargeable FM/AM radio, 5-in-1 phone charger, and a custom charge cable. Consumers pay an upfront fee of about $30 for the M-Kopa 5, then a daily charge of $0.50 for one year, before full ownership, bringing the total cost of the system to $212.50. This is very steep for an 8Wp system. For the M-Kopa 400 system, a deposit of $80 is required, then a daily payment of $1.25 for one year, before full ownership, bringing the total cost of the system to $536.25. This is also very steep, compared to market prices of similarly sized systems. Most households in rural sub-Saharan Africa can hardly afford $2 a day. In Kenya, for example, 50% of households live below the poverty line, and most of these people are the ones targeted by small solar home systems. The M-Kopa systems are therefore out of reach of many rural households in sub-Saharan Africa. The table below shows the M-Kopa systems

M-KOPA SYSTEMS	M-KOPA 5: 8W Panel with control unit and Lithium Battery, 4 1.2W LED bulbs, Rechargeable Torch, Rechargeable Radio, 5-in-1 Phone Charger			M-KOPA 400: 20W Panel with control unit and Lithium Battery, 3 1.2W LED bulbs, Rechargeable Torch, Rechargeable Radio, 5-in-1 Phone Charger		
	Kenya (KES)	Tanzania (TZS)	Uganda (USH)	Kenya (KES)	Tanzania (TZS)	Uganda (USH)
Deposit	2,999	49,000	119,999	7,999	69,000	300,000
Daily Charge	50	1,000	2,500	125	1,000	4,200
Total Cost	21,249	414,000	1,032,499	53,624	434,000	1,833,000
Total Cost in US$	**202**	**183**	**281**	**511**	**382**	**498**
Typical Cash Market Price (US$)	**71**			**167**		

Table 2: Main M-Kopa Systems Sold in East Africa

3.3.2Mobisol

Mobisol operates in many developing countries and offer four main systems rated 80, 100, 120, and 200Wp. Each system comes complete with LED light bulbs, a portable lantern, a mobile phone charger, battery, and balance-of-system components. They offer a 36 months' pay-as-you-go plan via various mobile money planforms, enabling consumers without bank accounts to purchase the systems [27]. The Mobisol systems are better-sized for productive use than the M-Kopa systems, and provide enough energy beyond lighting for small rural businesses. They are also more expensive than the M-Kopa systems due to larger sizes, but provision of microcredit facilities enables pre-qualified customers to purchase the systems. Mobisol boasts of 30,000 sales in Tanzania. The table below Shows the Mobisol systems.

MOBISOL SYSTEMS	BUFFALO: 80W, 45Ah Battery, 3 LED Bulbs, 4 Years Warranty	HIPPO: 120W, 65Ah Battery, 3 LED Bulbs, 4 Years Warranty	ELEPHANT: 200W, 100Ah Battery, 3 LED Bulbs, 4 Years Warranty
	Kenya (KES)	Kenya (KES)	Kenya (KES)
Deposit	4,640	6,960	9,960
Daily Charge	59	89	139
Total Cost	69,245	104,415	162,065
Total Cost in US$	**670**	**994**	**1,543**
Typical Cash Market Price (US$)	**238**	**333**	**619**

Table 3: Main Mobisol Systems Sold in East Africa

3.3.3Azuri Technologies

Azuri offers Indigo Duo and Azuri Quad SHS [24]. They manufacture the systems and sell them to local partners for distribution, installation, servicing, and financing. In addition to offering pay-as-you-go SHS, Azuri has joined with a local home entertainment satellite provider in Kenya, Zuku, to provide a combined package of SHS, a 24" DC TV, and satellite dish and Zuku Smart+ entertainment with 54 TV and 21 radio channels. This package costs about $1.50/day. Typically, the Azuri SHS system comes with four LED lamps, mobile phone charger, and portable and rechargeable radio and is paid for over 2 years. Azuri is operational in 12 African countries and has installed about 90,000 SHS in those countries.

3.3.4Off-Grid Electric

Just like the above companies, Off-Grid Electric offers SHS through a P-A-Y-G mobile money platform, and using survey to peg their prices below a household's average daily expenditure on alternative sources of energy [28], usually kerosene. They have installed over 50,000 systems, especially in Tanzania. Each of their systems is rated between 20-25Wp and comes with a 12V Li-Ion battery. Off-Grid also offers electricity as a service to customers in Rwanda and Tanzania, with an option of ownership after 10 years. They are active across the whole value chain, i.e., from manufacturing to installation and servicing .

4 CONCLUSION

Technology leapfrog has seen the emergence of unique business models that have stimulated PV installations, and especially in East Africa. In Kenya, private companies are quickly overtaking development organizations as the main drivers of PV installations; lessons from past projects, successful or otherwise, have produced a number of localized and proven business models that have led to productive use of electricity for new electricity-based enterprises that in turn bolster the revenues of energy companies. Specialized businesses have emerged, from companies specializing in energy trade, to those specializing in specific technical hardware. Advancements in technology such as mobile money platforms, locally designed smart meters, satellite imagery, etc. have rapidly driven down the cost of setting up and running energy systems and businesses. Reduced business costs have in turn translated into affordable electricity for the end consumers, leading to increased connections. This has led to higher returns for investors. Innovative mobile money platforms, with the main one being MPesa, has created an atmosphere of financial inclusivity, enabling people in remote rural areas to carry out financial transactions over long distances using the most basic of mobile phones, thus connecting them to the formal economy. In addition to creating many avenues for trade, job creation, and innovation, the mobile money platforms have also acted as catalysts for innovating energy models, access, and trade. Now, most businesses

involved in energy generation and trade rely on MPesa for their financial transactions. This enables remote running and operation of energy generation and management systems. The energy consumers also use MPesa to pay for their power, and to modify their power bundles according to their needs/incomes

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